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Acquisition of a Complex Basketball-Dribbling Task in School Children as a Function of Bilateral Practice Order

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The purpose of this study was to investigate order-of-practice effects for the acquisition of a complex basketball skill in a bilateral transfer paradigm. The task required participants to dribble as fast as possible in slalom-like movements across six javelins and return to the initial position. Fifty-two right-handed school children (M age = 11.7 years) practiced this skill in eight sessions over 4 weeks under one of two training schedules: (a) with the dominant hand, before changing to their nondominant hand (D-ND group), or (b) with the nondominant hand, before changing to the dominant hand (ND-D group). All tests were conducted with the right hand or the left hand only, and a transfer test was given with both hands alternating. The results of a retention test yielded significantly larger learning gains for the ND-D group as compared to the D-ND group. It is interesting that this performance advantage was independent of the respective hand tested. The same pattern of result was found in the transfer test, with significantly shorter movement times for the ND-D group with both hands alternating. Such order-of-practice effects for the acquisition of complex skills can be explained with hemispheric brain asymmetries for the processing of specific task requirements.

Key words: early motor learning, hemispheric specialization, intermanual transfer

Modern game sports such as basketball or soccer require athletes to execute complex skills not only on their preferred side using their dominant hand (or foot), but also on their nonpreferred side. Especially in competitive play, when athletes face pressure from opponents and when they have to select an appropriate action under time constraints, the flexible use of the dominant and nondominant hand (or foot) is crucial for successful play. For example, in order for a basketball player to shield the ball from an opponent, he or she must be able to dribble equally well with the dominant and the nondominant hand. Similarly, a player should be able to rebound a loose ball returning from the rim with the dominant or nondominant hand. These and other situations render the variable use of complex sport skills on both sides of the body a necessity for successful play in modern game sports. While this principle is shared by most coaches and athletes, the issue of systematic bilateral skill acquisition is often neglected in today's practice schedules. The purpose of the present study was to investigate the effects of two bilateral practice schedules on the acquisition of a basketball dribbling skill.[1]

It is well documented that practicing a motor skill with one hand (or foot) can also result in performance improvements in the opposite (contralateral) effector (e.g., Criscimagna-Hemminger, Donchin, Gazzaniga, & Shadmehr, 2003; Sainburg & Wang, 2002; Teixeira, 2000). Most research studies in support of such intermanual transfer effects have focused mainly on simple movement tasks, such as finger tapping (Laszlo, Baguley, & Bairstow, 1970), writing and drawing (e.g., Parlow & Kinsbourne, 1989; Raibert, 1977), key pressing (Taylor & Heilman, 1980), pursuit rotor tracking (e.g., Byrd, Gibson, & Gleason, 1986; Parker-Taillon & Kerr, 1989), or pointing during visuo-motor perturbations (e.g., Sainburg & Wang, 2002, Wang & Sainburg, 2004a) as well as dynamic perturbations (Wang & Sainburg, 2004b). However, there have

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also been some transfer studies using more complex tasks, such as dribbling and kicking skills in soccer (Haaland & Hoff, 2003; Teixeira, Silva, & Carvalho, 2003), throwing in basketball (Stöckel, Hartmann & Weigelt, 2007), and performing particular dance routines (Puretz, 1983). It is interesting that all of these studies have reported asymmetrical transfer between two homologous limbs, indicating that the amount of skill transfer varies from one side of the body to the other side. Therefore, and despite the differences between these previous studies (e.g., differences in task complexity, the amounts of practice, and the level of proficiency), they suggest sequential effects on the acquisition of motor skills, such as that the initial side of the body practiced (dominant vs. nondominant) influences the amount of skill transferred to the other side. Following this notion, systematic investigations of such sequential effects on the acquisition of complex motor skills after equally distributed practice with the dominant and nondominant hand (or foot) are required to provide a better picture of how the acquisition of complex motor skills should be structured.

One approach for systematically investigating sequential effects after initial practice with the dominant versus nondominant hand (or foot) is to consider the inherent task parameters and/or the underlying motor components specifying a particular motor skill (e.g., Carson, 1989; Sainburg, 2002; Teixeira, 2000). This approach is in line with Sainburg's (2002) dynamic-dominance hypothesis of handedness and the proposal that independent neural systems control different movement features. In this regard, a greater proficiency of the left-brain–right-hand system has been demonstrated in the control of trajectory dynamics, while the right-brain–left-hand system appears to better specify the final position of a movement (e.g., Bagesteiro & Sainburg, 2003; Sainburg & Kalakanis, 2000; Sainburg & Wang, 2002; Wang & Sainburg, 2004b). Also, some evidence suggests at least partial transfer of force control from the dominant, right limb, to the nondominant, left limb (Criscimagna-Hemminger et al., 2003; Farthing, Chilibeck, & Binsted, 2005; Teixeira & Caminha, 2003). Sainburg's (2002) dynamic dominance hypothesis also fits with a more general model of brain asymmetries and hemispheric specialization, which assumes that distributed brain networks are cooperating during motor performance (e.g., Birbaumer, 2007; Serrien, Ivry, & Swinnen, 2006). Thereby, it is understood that "both hemispheres are likely to be involved in the performance of any complex task, but with each contributing in their specialized manner" (Gazzaniga, Ivry, & Mangun, 1998, p. 369).

While much research confirms asymmetric transfer after dominant and nondominant hand (or foot) practice of simple motor tasks, physical education teachers and other practitioners are especially interested in such sequential effects on the acquisition of complex sport skills. Two recent studies investigated sequential effects after extended practice of the dominant and nondominant leg in experienced, adolescent soccer players (Haaland & Hoff, 2003; Teixeira et al., 2003). Haaland and Hoff (2003) tested two groups using two standardized foot-tapping tasks (two- and three-position foot-tapping) and three soccer-specific tests (dribbling, volley goal shot, and passing against a mini-goal). During a training period over several weeks, one group used only their dominant leg and the other group used their nondominant leg. As expected, the nondominant leg group performed better across all tasks when tested with the nondominant leg after the training period. Most surprisingly, however, the nondominant leg group also showed greater performance improvements when tested on their dominant leg (when compared to the dominant leg group). Thus, nondominant leg training led to a general improvement of skill performance on both sides of the body, even in experienced soccer players. These results were at least partially confirmed in another study by Teixeira et al. (2003), who found a similar reduction of lateral asymmetries in a soccer dribbling task after nondominant leg practice (but no reduction in two other tasks, kicking for force and kicking for accuracy).

Note that in the previous two studies, participants practiced either with their dominant or their nondominant limb over a certain period of time before performance was assessed on both sides in a posttest. What is unknown from these studies is (a) whether nondominant limb practice improves performance *per se*, or (b) if it matters at what point in time the dominant or the nondominant limb is being practiced. The earlier study supports rather unspecific effects of nondominant limb practice on skill acquisition, whereas the second is reminiscent of sequential effects on motor skill learning.

In recent studies, we looked at this question by adding another period of opposite limb practice after initially training the dominant or nondominant limb (Senff & Weigelt, 2011; Stöckel et al., 2007; Stöckel & Weigelt, 2011). Stöckel et al. (2007) had two groups of adolescent participants practice a basketball shooting task, involving the dominant and nondominant hand in opposite training schedules over several sessions (with the amount of practice on each side counterbalanced). The results of this study demonstrated improved bilateral performance (i.e., greater shooting accuracy with the dominant and the nondominant hand) for the training group that started to learn the basketball task with their nondominant hand first. Similar results were obtained by Senff and Weigelt (2011), who asked children to slide cent coins from a starting position into a target on the opposite side of a table. Again, two groups practiced this task in opposite training schedules, using their dominant and nondominant hand equally often across the whole period of the study. The children who practiced this task initially with the nondominant hand performed better afterwards with both hands, displaying greater sliding accuracy on their dominant and on their nondominant side. Hence, these studies show sequential effects both for the acquisition of a complex sport motor skill (Stöckel et al., 2007) and for a simple perceptual-motor task (Senff & Weigelt, 2011). The term "sequential effects" refers to the observation that the order in which both hands are practiced influences how well a particular skill will be learned.

The purpose of this study was to investigate sequential effects on the acquisition of a complex dribbling task in basketball. To this end, we recruited a group of young children, because young learners are most often confronted with the task of acquiring a novel sport skill (e.g., in physical education classes). The findings of the present study should therefore have high practical relevance for the organization and optimization of children's training schedules. Two groups of young children were asked to dribble a basketball around a slalom course using either their dominant or nondominant hand at different times over a series of training sessions. Most importantly, both practice schedules were designed to provide the same amount of bilateral skill training (i.e., the amount of time spent practicing with the dominant and the nondominant hand). We made one specific and two general predictions. The two general predictions were (a) if the order in which children practice their hands has no effect on the acquisition of this dribbling task, then we should observe no differences in performance between the two groups; or (b) contrarily, if sequential effects manifest themselves on the acquisition of the present task, then we should observe performance differences. The more specific prediction was that if the previously reported sequential effects (Stöckel et al., 2007; Senff & Weigelt, 2011) extend to dribbling skills, which require the integration of visual-spatial information (e.g., while moving through an obstacle course), then the children who start to practice the task with their nondominant hand should show greater performance improvements.

Method

Participants

Fifty-two school children (17 girls and 35 boys) from the sixth and seventh grades (ranging in age from 11 to 13 years, *M* age = 11.7 years, *SD* = 1.0) of a grammar school participated in this study. All of them were right-handed.[2] The handedness of all children was assessed with the Edinburgh Handedness Inventory (Oldfield, 1971) before the study, and none of the children had prior experience with the task or played on a basketball team outside of the school. Before the experiment, all of the children's parents gave their informed consent for their child's participation in the study. The study took place during regular physical education classes. The local school authorities and the institutional review board approved the research.

Task

The present task was a modified version of a task previously used by Teixeira et al. (2003). While these authors tested the speed of dribbling for a slalom-dribbling task (SDT) in soccer, we investigated dribbling in basketball. The SDT required participants to dribble around an obstacle course of six javelins, arranged in a straight line and spaced apart by 1.5 m (see Figure 1). The total distance from the start/ finish line to the last javelin was 9 m. Each trial started with the participant crossing the starting line. He or she then dribbled around each javelin, circled the last javelin, and returned as fast as possible to the finish line (bypassing the javelins on the way back). Participants started whenever they felt ready. They had to circle the javelins by using the right hand only, the left hand only, or alternating between the two hands. The time it took participants from start to finish was measured with a stopwatch, which automatically started and stopped when a light barrier was crossed, approximately at shin height (longines TL2000 measurement device; Longines, St. Imler, Switzerland). To this end, the photoelectric sensor and the reflector of the longines TL2000 measurement device were arranged at a height of 30 cm, so that the light barrier covered the start/finish line (see Figure 1, SDT). The basketball used was of official size, approximately 75 cm in circumference and with a weight of approximately 600 g.

The need to keep good control over the ball under time pressure renders the SDT a complex task, requiring a great deal of visual-spatial coordination while dribbling through the obstacle course. The specific demands of the SDT therefore require the integration of visual-spatial information and the coordination of movements under time pressure.

Design and Procedure

The 52 participants were equally distributed to one of two groups after a pretest. The two groups then practiced the SDT under one of the following two treatment conditions: (a) participants dribbled with their dominant hand for the first four of the eight practice sessions and then switched to their nondominant hand for the second four (D-ND group); or (b) participants dribbled with their nondominant hand for the first four of the eight practice sessions and then switched to their dominant hand for the second four (ND-D group). This fully crossed order-of-practice design ensured that all participants learned the skill for the same amount of time with their dominant and nondominant hand. The only difference between the groups was the point in time at which the dominant or nondominant hand was practiced. After the completion of all practice sessions, any difference observed in the dependent variable (i.e., dribbling speed) must be attributed to the difference in practice order.

This study lasted 6 weeks and included a pretest, eight practice sessions, a posttest, a retention test, and a transfer test. Both the retention test and the transfer test were conducted after one week without practice. All testing and training sessions were arranged during regular physical education lessons in a school gymnasium. These lessons included basic exercises of ball handling and a number of different drills with the aim to (methodologically) improve participant's dribbling abilities.

In the pretest, participants were tested separately with their left and right hand (order counterbalanced across participants). Each hand was tested only once, unless participants made a mistake while performing the task, such as dribbling on the base of the javelin or leaving one out. Such error trials were repeated after the participant had recovered. The participant's performance was assessed on an individual basis. Before the first participant was tested, the experimenter demonstrated the dribbling skill with the left and right hand, and the participants had one practice trial with each hand to become familiar with the task procedure. Based on their pretest results, all participants were assigned to one of the two experimental groups, balancing the initial performance level between both groups. That is, the total times to finish the SDT in the pretest were transformed to a rank order from low to high values (averaged over both hands) and all participants on an odd rank were assigned to the D-ND group and participants on an even rank were assigned to the ND-D group.

In the learning phase (practice sessions), participants practiced basketball in their respective group under one of the two order-of-practice schedules. A total of eight practice sessions were administered over a period of 4 weeks. Each session lasted for 45 min. The two groups practiced separately and according to their assignment (D-ND vs. ND-D). The children used either only their dominant or their nondominant hand for *all* the skills performed during these sessions. Each session followed a methodological procedure commonly used by practitioners to teach children's basketball (e.g., Mondoni, 2000; Vancil, 1996). The content of practice (i.e., the drills performed) included different warm-up exercises, dribbling in various ways, a number of ball-handling skills other than dribbling, and different forms of game-play (using the part-whole-method). A complete list of the exercises used during the different practice sessions is provided in the Appendix. Most importantly, the content of practice and the amount of training in each session, as well as the number of repetitions for each exercise, were identical for both groups. However, they never practiced the standardized SDT used as a test in this study, and no additional data were collected during the learning phase. Instead, we used the standardized test (i.e., SDT) to investigate the effects of hand-order during an otherwise regular basketball training schedule.

During the intervention, each drill and exercise had to be performed with the one hand for the first four sessions and with the other hand for the remaining four sessions, depending on the participant's group affiliation. While the D-ND group first practiced with their dominant hand and changed to the nondominant hand, the ND-D group practiced in opposite hand order. The same drills of Sessions 1–4 were used again in Sessions 5–8 for the contralateral hand.

The posttest followed immediately after the learning phase was completed. Again, each participant was tested on an individual basis, performing the SDT with his or her left and right hand. The procedure of the posttest was similar to the one of the pretest. The retention test followed after 1 week without practice, and involved the left and right hand in the SDT. Testing for retention was done to look at more permanent changes in performance (i.e., learning; Schmidt & Lee, 2005). Furthermore, we were interested whether participants were able to use the newly learned skill under game-like situations (i.e., dribbling with both hands). Therefore, the transfer test required participants to perform the SDT using the left and right hand in an alternating fashion. More specifically, the participants were instructed to dribble around each javelin while using the outer hand. This required them

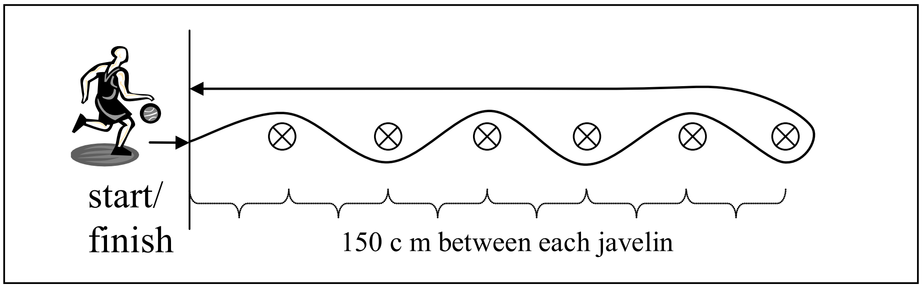

Figure 1. Depiction of the experimental set-up of the Slalom-Dribble-Test, which required participants to dribble as fast as possible in a slalom-like movement to the last javelin and return to the initial position.

to change hands and to perform a cross-over dribbling move after each javelin. This modification was included to simulate a game situation, where it is important to shield the ball from a defender by bringing one's body between the ball and the defender and dribbling the ball with the "outer" hand (i.e., the hand away from the defender).

Dependent Variables and Data Analysis

The total time (in seconds) that participants needed to finish the slalom obstacle course was measured by the experimenter and collected for each hand separately for the pretest, the posttest, and the retention test. This data was then submitted to a 2 (group: D-ND vs. ND-D) x 2 (hand: dominant vs. nondominant) x 3 (test: pretest vs. posttest vs. retention test) analysis of variance (ANOVA), with repeated measures on the last two factors. The factor group was tested between participants. The three-way ANOVA was performed to analyze trials only conducted with one hand (primary SDT conditions in the pretest, posttest, and retention test). To analyze participants' performance in the transfer task (i.e., dribbling while alternating between hands), a separate one-way ANOVA was calculated on the transfer test data.

Results

One-Hand Dribbling (Primary SDT Conditions)

The total times needed to finish the obstacle course with the dominant, right hand for the D-ND group were 9.38 s (pretest), 8.73 s (posttest), and 8.54 s (retention test), and for the ND-D group were 9.28 s (pretest); 8.15 s (posttest), and 7.88 s (retention test). The total times with the nondominant, left hand for the D-ND group were 9.97 s (pretest), 9.08 s (posttest), and 9.28 s (retention test), and for the ND-D group were 9.94 s (pretest); 8.72 s (posttest); and 8.30 s (retention test). Figure 2 illustrates the greater rate of improvement (i.e., faster dribbling times) experienced by the ND-D group for the averaged total times, collapsed across the two hands across the series of tests.

The analysis of the one-hand dribbling conditions yielded a significant main effect for test, $F(2, 100) = 31.61$, $p < .001$, $\eta^2 = .38$, indicating an improvement of the dribbling skill for all participants over the course of the study. The averaged dribbling times to finish the obstacle course were 9.64 s (pretest), 8.67 s (posttest), and 8.50 s (retention test). Simple contrasts revealed the difference of 0.97 s between pre- and posttest and the difference of 1.15 s between pretest and retention to be significant (both $p < .001$). The main effect for hand, $F(1, 50) = 44.91$, $p < .001$, $\eta^2 = .46$, was also significant, showing that the participants dribbled faster with their dominant, right hand (8.66 s) than with their nondominant, left hand (9.22 s). Most importantly, the Group x Test interaction proved to be significant, $F(2, 100) = 3.86$, $p < .05$, $\eta^2 = .07$. Simple contrasts were performed to reveal differences at the posttest and retention test level. The performance differences between the two groups in the posttest were not significant. The difference of 0.82 s between the D-ND and ND-D group in the retention test, however, proved to be statistically significant ($p < .05$), indicating shorter dribbling times for the ND-D group. The average dribbling times of the D-ND group improved from pre- to posttest by 0.77 s, and from pretest to retention test by 0.77 s. The improvement for the ND-D group was 1.18 s from pre- to posttest and 1.53 s from pretest to retention test. These performance differences between the two groups were obtained similarly

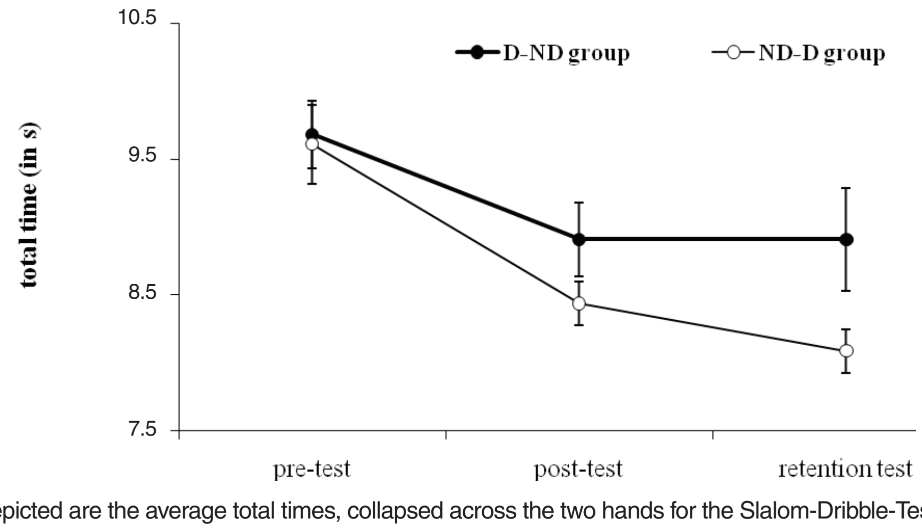

Figure 2. Depicted are the average total times, collapsed across the two hands for the Slalom-Dribble-Test at pre-, post- and retention tests for the dominant-to-nondominant group (D-ND, solid circles) and the nondominant-to-dominant group (ND-D, open circles).

for the nondominant and the dominant hand, which can be inferred from the absence of an interaction effect of the hand factor with any other factor.

Dribbling With Both Hands Alternating (Transfer SDT Conditions)

The total times that participants needed to finish the obstacle course while alternating between the dominant, right and nondominant, left hand were 7.77 s for the D-ND group and 7.09 s for the ND-D group. A one-way ANOVA (with 25 participants in each group, because 2 missed the transfer test) was calculated, and the difference between the dribbling times for the two groups proved to be significant, $F(1,48) = 3.42$, $p < .05$, $\eta^2 = .07$. This shows that participants in the ND-D group transferred the previously learned dribbling skill better to the game-like situation simulated in the transfer test.

Discussion

This study provides evidence for sequential effects on the acquisition of a basketball dribbling skill with high demand on the integration of visual-spatial information, as well as on the speed of movement (Teixeira et al., 2003). Performing this task with high speed requires a person to efficiently orchestrate the innervations of the whole neuromuscular system for the control of different body parts, and thus the coordination of many degrees of freedom (Bernstein, 1967). To coordinate one's movement in space requires the alignment of the body to external objects and events. For the former, performance is based on a motor sequence mechanism, while for the latter, performance is based on a spatial sequence mechanism. Hikosaka and colleagues (Hikosaka et al., 1999; Hikosaka, Nakamura, Sakai, & Nakahara, 2002) put forward a model of motor skill acquisition that proposes that motor learning is faster when performance relies on a spatial sequence mechanism than when it is based on a motor sequence mechanism. With regard to the present study, circumnavigating the javelins, and, thus, coordinating one's own movements relative to external objects (spatial sequence mechanism) may be learned faster than moving at high speed (motor sequence mechanism), given the task constraints at hand (i.e., dribbling). Here, the early involvement of the right-brain-hemisphere–left-hand system benefits the task-specific learning of a spatial sequence mechanism, which is reflected by greater performance improvements of the ND-D group. This view is further discussed in the following paragraph, in which we attempt to answer the question of how the observed effects relative to the particular hand-order can be explained.

One possible answer to the question raised above relates to the notion that the optimal initial practice side depends on the inherent motor components of the task (see Carson, 1989; Sainburg, 2002; Teixeira, 2000). This notion receives support from recent findings in the field of neuroscience, providing evidence for task-specific differences in hemispheric activation for the control of different task demands (see Birbaumer, 2007; Serrien et al., 2006, for an overview). Here, the following picture in terms of hemispheric specialization and task control emerges: While the left brain hemisphere is primarily responsible for the temporal and sequential control of movements (i.e., the control of movement trajectories) and the regulation of dynamic aspects (i.e., fine-force control), the spatial orientation and coordination of actions (i.e., the control of final positions and targeted precision) are processed in the right brain hemisphere (see Sainburg, 2002, dynamic dominance hypothesis; or Serrien et al., 2006, for an overview). With regard to a more general model of hemispheric specialization (e.g., Gazzaniga et al., 1998), it is assumed that the most efficient processing of visual-spatial information in the right brain hemisphere will benefit a specialized hemisphere-effector system in favor of the left hand in tasks with high spatial-accuracy demands. The dribbling task in our study required a great deal of visual-spatial processing when circumnavigating the javelins. Therefore, we propose that initial practice with the left hand will result in better acquisition of the skill, because the specialized right-brain–left-hand system is more efficient in processing visual-spatial information. As a consequence, this may lead to a better transfer of information to the contralateral hemisphere and the untrained hand, compared to training with the nonspecialized and less efficient hemisphere-effector system.

The present results can be explained not only by positive interlimb transfer effects after practicing with the specialized hemisphere-effector system, but by proactive and retroactive interference effects. Such interference effects are well known phenomena in motor learning, and they frequently occur during the acquisition of two similar tasks (e.g., Goedert & Willingham, 2002; Krakauer, Ghilardi, & Ghez, 1999; Panzer, Wilde, & Shea, 2006). Interference can be proactive when the consolidation processes of the first task interfere with the acquisition of a second task (the second task suffers), or they can be retroactive when the consolidation of the first task is disturbed by the acquisition of the second task (the first task suffers; cf. Zach et al., 2005). Hence, while positive interlimb transfer effects may have been responsible for better skill learning with the dominant hand after practicing the task with the nondominant hand (and thus with the specialized hemisphere-effector system), proactive interference effects could have hindered the acquisition with the nondominant hand after the skill had been trained first with the dominant hand (and thus with the nonspecialized hemisphere-effector system). At the same time, retroactive interference effects may have disrupted the consolidation processes of the skill acquired previously with the dominant hand. As a result, the participants of the ND-D group benefited from the particular hand order in which they practiced the dribbling skill, whereas the D-ND group suffered from the opposite schedule.

From a practitioner's point of view, the present findings provide further insight about how to schedule the training process during the acquisition of new motor skills. Movement techniques demanding high spatial accuracy and coordination (such as high-precision throwing skills) should be taught differently during the acquisition phase, as compared to tasks with a high demand on force production and control (such as forceful throwing skills). Moreover, coaches and trainers working with young athletes should pay attention to the specific task demands inherent in certain motor skills. The early training process should focus on the issue of task specificity. The question of what should be achieved through skill acquisition by the athletes on a long-term basis is of main importance, because a flexible availability of specific skills with both limbs may be the ultimate goal of skill practice (like in game sports). Therefore, coaches and trainers working with young athletes should take a critical look at their training schedules with the intention of creating more effective practice by taking the initial hand-order in skill acquisition into account.

Conclusion

In summary, the present study provides further evidence for task-specific effects of hand-order during the acquisition of complex (sport) motor skills. Most importantly, the order of practice of the dominant and nondominant limbs in the initial training schedule seems to be important to improve performance of both limbs and to strengthen the bilateral competence of the learners. This was shown in the present study for adolescent children, who are an especially interesting group of learners, since basic sport skills are taught at young ages. However, the present results are restricted to right-handed participants. Future studies should therefore be conducted to examine whether such sequential effects generalize to left-handed participants. So far, left-handers have often been neglected in motor learning research, although they seem to be overrepresented at high levels for a number of sports (e.g., Harris, 2010).

In light of former studies reporting opposite effects of nondominant and dominant hand (or foot) practice on the acquisition of simple and complex motor tasks, the present study provides further information about how to schedule initial skill learning and to organize the training processes. The present findings should therefore be of particular interest to coaches and physical therapists, who have to schedule practice sessions either for learning novel skills or for relearning a skill after injury, which may be further accompanied by lateral deficits (e.g., in stroke patients).

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Notes

1. Here we refer to “bilateral” to indicate practice on both sides of the body, similarly using either the dominant or nondominant hand (or foot). This is different from the term bimanual, which has been used in motor control research to indicate the simultaneous coordination of both hands.

2. Also, 9 left-handed children participated in the present study. For pedagogical reasons, we did not want to exclude these children from participating in the activity simply because they were left-handed. Their sample, however, was much too small to derive any valid conclusions from their results. Consequently, we decided to omit data for the left-handed children and examine only the right-handed children’s performance.

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Appendix.

Overview of topics and content for the various practice sessions (1–8) on acquiring the basketball dribbling skill. Participants performed all exercises for Sessions 1–4 using one hand only (dominant or nondominant) and repeated Sessions 5–8 with the other hand. Listed are the specific exercises for each session, focusing on ball handling and dribbling basics on the spot (Sessions 1 and 5), on dribbling basics in slow motion (Sessions 2 and 6), dribbling basics in fast motion and with obstacles (Sessions 3 and 7), and advanced dribbling under competitive conditions (Sessions 4 and 8).

Session	Topic and content	Exercises	Repetitions and task criteria
1 and 5	Ball handling basics	Circle training with five exercises: Figure eight (roll dribbling) Wall drill (1 m) Tap drill (with partner) Finger flip (various heights) Hand-off drill (with partner)	The circle had to be completed three times 30 s per exercise No rest after completing all exercises
	Dribbling basics on the spot	All children dribble the ball in a circle around the coach: Basic technique of dribbling (i.e., hand and feet position, head up) Simple dribbling (technique) High-low dribble Left-right dribble in front of the body Back and forth beside the body Combined while sitting (imitate the coach) “One-bounce” dribbling (synchronized)	Explanations and demonstrations in Part A lasted for 5 min Each part lasted 3 x 30 s Corrections and further explanations were provided concurrently
Effective dribbling time: 16 min 30 s in continuous dribbling			
2 and 6	Dribbling basics in slow motion	Full-court (25 m) dribbling in slow motion: Basics of dribbling in motion (i.e., leg, hand, and ball position in low dribble) Dribble rhythm (normal) walking dribble Onside dribble Change dribble rhythm at each line Sideward dribbling Backwards dribbling Change-of-direction (each line) Forth and back drill Change-of-pace (whistle) Head up (imitate the coach, all drills combined)	All children start dribbling at the baseline Explanations and demonstrations in Part A lasted for 5 min Each exercise was practiced by dribbling twice from baseline to baseline and back in slow motion The last Part K had to be completed five times Corrections and explanations after each line
Total amount of dribbling: Each participant dribbled 46 lanes (25 m) in slow motion.			
3 and 7	Dribbling basics in fast motion (and with obstacles)	Full-court dribbling in fast motion: Basics of dribbling in fast motion (i.e., dribble rhythm; leg, hand and ball position in high dribble) High dribble Stop and go (stop at each line) Pull-back drill Sideward dribbling Stop and go with a partner tight behind each other Fast dibbling with circumventing three cones on one lane Like (g) plus dribbling across a bench in the middle of the lane Like (h) plus turning around a ball with the free hand on this ball (each baseline) Like (g) but backward	All children start dribbling at the baseline (two lines) Explanations and demonstrations in Part A lasted for 5 min Each drill was practiced by dribbling 3 times from baseline to baseline and back in fast motion Corrections and explanations after each line Never stop the dribbling Never change the hands
Total amount of dribbling: Each participant dribbled 54 lanes (25 m) in fast motion.			

Appendix. (cont.)

4 and 8	Advanced dribbling under competi-tive condi-tions	Dribbling competition: Speed dribble (touching the baseline with the baton) Like (a) with a handball Like (a) with a rubber foam ball Like (a) with a tennis ball Like (a) with a table tennis ball Like (a) plus circumventing three cones on each lane Like (f) plus jumping over two obstacles on each lane Like (g) plus dribbling while balancing across a reversed bench in the middle of the lane Like (h) plus circumventing a medicine ball two times while touching it with the baton Like (a) but backward Like (d) but backward Like (f) but backward Like (i) plus touching each baseline with the bottom Suicide dribble	Competition among three groups (starting at baseline) in a full-court dribbling parcourse Baton and basketball had to be passed to the next person in the group Each parcourse had to be completed twice Never stop the dribbling Never change the hands
Total amount of dribbling: Each participant dribbled 48 lanes (25 m) in fast motion around the various obstacles.			